National Institute of Standards & Technology

Certificate of Analysis

Standard Reference Material® 173c

Titanium-Base Alloy (6Al-4V)

(In Cooperation with ASTM International)

This Standard Reference Material (SRM) is intended primarily for use in evaluating chemical and instrumental methods of analysis of titanium and its alloys. A unit of SRM 173c consists of a single bottle containing approximately 50 g of chips.

The certified values for six constituents in SRM 173c are listed in Table 1. Reference values for eight constituents are listed in Table 2. Information values for six constituents are listed in Table 3. All values are reported as mass fractions on an as-received basis [1]. Value assignment categories are based on the definition of terms and modes used at NIST for chemical reference materials [2], and uncertainties are assessed according to the ISO and NIST Guides [3]. Analytical methods employed in the development of this material are listed in Table 4.

Certified Values: A NIST certified value is a value for which NIST has the highest confidence in its accuracy, in that all known or suspected sources of bias have been investigated or accounted for by NIST. A certified value is the present best estimate of the "true" value based on the results of analyses performed at NIST and cooperating laboratories using the test methods listed in Table 4. The uncertainty listed with the value is an expanded uncertainty (95 % confidence interval [4]) and is calculated according to the method in the ISO and NIST Guides [3].

Reference Values: Reference values are non-certified values that are the present best estimates of the true values. However, the values do not meet the NIST criteria for certification and are provided with associated uncertainties that may not include all components of uncertainty. The uncertainty listed with the value is an expanded uncertainty (95 % confidence interval [4]) and is calculated according to the method in the ISO and NIST Guides [3].

Information Values: An information value is considered to be a value that will be of interest and use to the SRM user, but insufficient information is available to assess the uncertainty associated with the value.

Expiration of Certification: The certification of this SRM is valid until **01 April 2024**, within the uncertainty specified, provided the SRM is handled and stored in accordance with the instructions given in this certificate (see "Instructions for Use"). However, the certification will be nullified if the SRM is damaged or contaminated.

Stability: This material is considered to be stable during the period of certification when stored in its original container in a cool, dry location. NIST will monitor this material and will report any significant changes in certification to the purchaser. Registration (see attached sheet) will facilitate notification.

The overall direction and coordination of the technical measurements leading to the certification of this SRM were performed by J.R. Sieber of the NIST Analytical Chemistry Division.

Analytical measurements from NIST for certification of this SRM, including homogeneity testing, were performed by J.R. Sieber and A.F. Marlow of the NIST Analytical Chemistry Division.

Statistical consultation was provided by S.D. Leigh of the NIST Statistical Engineering Division.

Willie E. May, Chief
Analytical Chemistry Division

Gaithersburg, MD 20899
Certificate Issue Date: 30 July 2004
See Certificate Revision History on Last Page

Robert L. Watters, Jr., Acting Chief
Measurement Services Division

The material for SRM 173c was obtained from Allvac[1], Monroe, North Carolina. The material was chipped, blended and bottled at NIST under the supervision of M.P. Cronise of the Measurement Services Division.

The support aspects involved in the issuance of this SRM were coordinated through the NIST Standard Reference Materials Program by B.S. MacDonald of the NIST Measurement Services Division.

INSTRUCTIONS FOR USE

To relate analytical determinations to the values on this Certificate of Analysis, a minimum sample quantity of 250 mg should be used. The material may be used directly from the original container. Sampling and sample preparation procedures should be designed to avoid material segregation on the basis of chip size. It is recommended to mix the contents of the bottle prior to sampling by turning the bottle end over end for two minutes.

Table 1. Certified Values for SRM 173c

Constituent	Value (mass fraction, %)	Expanded Uncertainty (mass fraction, %)
Al	6.245	0.036[a]
V	4.154	0.016[a]
Fe	0.2130	0.0040[a]
Cu	0.0040	0.0004[b]
Ni	0.0203	0.0009[a]
Cr	0.0165	0.0005[a]

Table 2. Reference Values for SRM 173c

Constituent	Value (mass fraction, %)	Expanded Uncertainty (mass fraction, %)
C	0.027	0.002[a]
N	0.028	0.005[b]
O	0.164	0.003[b]
Mo	0.0068	0.0004[a]
Si	0.019	0.005[b]
Ti	89.15	0.49
Zr	0.0053	0.0004[a]
Sn	0.010	0.002[b]

[1] The assigned value is a weighted mean of the results from two to seven analytical methods [5]. The uncertainty listed with each value is an expanded uncertainty about the mean, with a coverage factor 2 (approximately 95 % confidence), calculated by combining a between-source variance incorporating inter-method bias with a pooled within-source variance following the ISO and NIST Guides [3].

[b] The assigned value is an unweighted mean of the results from two to five analytical methods. The uncertainty listed with the value is an expanded uncertainty about the mean, with coverage factor 2, calculated by combining a between-method variance [6] with a pooled, within-method variance following the ISO and NIST Guides [3].

[1] Certain commercial equipment, instruments, or materials are identified in this report to adequately specify the experimental procedure. Such identification does not imply recommendation or endorsement by the NIST, nor does it imply that the materials or equipment identified are necessarily the best available for the purpose.

Table 3. Information Values for SRM 173c

Constituent	Value (mass fraction, %)
H	0.006
B	< 0.0005
Mn	0.002
Co	0.002
Ru	0.0006
W	0.002

Table 4. Analytical Methods

Method	Constituents Determined
Wavelength Dispersive X-Ray Fluorescence Spectrometry (WDXRF) at NIST	Al, Cr, Cu, Fe, Ni, Ti, V
Wavelength Dispersive X-Ray Fluorescence Spectrometry (WDXRF) at Cooperating Laboratories	Al, Cr, Cu, Fe, Ni, V, Zr
Inductively-Coupled Plasma Optical Emission Spectrometry (ICP-OES) at Cooperating Laboratories	Al, B, Co, Cr, Cu, Fe, Mn, Mo, Ni, Ru, Si, Sn, V, W, Zr
Direct Current Plasma Optical Emission Spectrometry (DCP-OES) at Cooperating Laboratories	Al, Cr, Cu, Fe, Mo, Ni, Si, V, Zr
Combustion with Infrared Detection at Cooperating Laboratories	C, N, O
Inert Gas Fusion at Cooperating Laboratories	H, N, O

Cooperating Laboratories: SRM 173c was produced in cooperation with ASTM International Committee E01 Analytical Chemistry of Metals, Ores and Related Materials, Subcommittee 06 on Ti, Zr, W, Mo, Ta, Nb, Hf. Analytical determinations for certification of this SRM were performed by the following laboratories:

Allegheny Ludlum; Brackenridge, Pennsylvania, USA; S. Bissell-Seymour and S. Cooper
Allvac; Monroe, North Carolina, USA; P. Cole
CEZUS; Ugine, France; L. Trecani
TIMET UK, Ltd.; Witton, Birmingham, England; M. Chamberlain-Webber
Titanium Metals Corp., Henderson Process Lab; Henderson, Nevada, USA; J. Kiely
Titanium Metals Corp., Henderson Technical Lab; Henderson, Nevada, USA; G. Boesenecker
Titanium Metals Corp.; Morgantown, Pennsylvania, USA; L. Creasy
Wah Chang; Albany, Oregon, USA; G. Beck

REFERENCES

[1] Taylor, B.N.; *Guide for the Use of the International System of Units (SI)*; NIST Special Publication 811: U.S. Government Printing Office: Washington, DC (1995).

[2] May, W.E.; Parris, R.M.; Beck II, C.M.; Fassett, J.D.; Greenberg, R.R.; Guenther, F.R.; Kramer, G.W.; Wise, S.A.; Gills, T.E.; Colbert, J.C.; Gettings, R.J.; MacDonald, B.S.; *Definitions of Terms and Modes Used at NIST for Value-Assignment of Reference Materials for Chemical Measurements*; NIST Spec. Pub. 260-136; U.S. Government Printing Office: Washington, DC, p. 16 (2000).

[3] ISO; *Guide to the Expression of Uncertainty in Measurement*; ISBN 92-67-10188-9, 1st ed.; International Organization for Standardization: Geneva, Switzerland (1993); see also Taylor, B.N.; Kuyatt, C.E.; *Guidelines for Evaluating and Expressing the Uncertainty of NIST Measurement Results*; NIST Technical Note 1297; U.S. Government Printing Office: Washington, DC (1994); available at http://physics.nist.gov/Pubs/.

[4] Hahn, G.J.; Meeker, W.Q.; *Statistical Intervals*: *A Guide for Practitioners*; John Wiley & Sons, Inc.: New York (1991).

[5] Ruhkin, A.L.; Vangel, M.G.; *Estimation of a Common Mean and Weighted Mean Statistics*; J. Am. Statist. Assoc.; Vol. 93, pp. 303-308 (1998).

[6] Levenson, M.S.; Banks, D.L.; Eberhardt, K.R.; Gill, L.M.; Guthrie, W.F.; Liu, H.K.; Vangel, M.G.; Yen, J.H.; Zang, N.F.; *An Approach to Combining Results from Multiple Methods Motivated by the ISO GUM*; J. Res. Natl. Inst. Stand. Technol.; Vol. 105, pp. 571-579 (2000).

Certificate Revision History: 30 July 2004 (Editorial changes to original certificate); 22 June 2004 (Original certificate date).

Users of this SRM should ensure that the certificate in their possession is current. This can be accomplished by contacting the SRM Program: telephone (301) 975-6776; fax (301) 926-4751; e-mail srminfo@nist.gov; or via the Internet http:// www.nist.gov/srm.